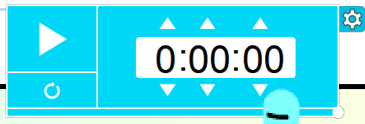
(g) the Boltzmann constant; $k = \frac{R}{N_A}$

(h) $pV = NkT$; $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$

Learners will also be expected to know the derivation of the equation $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ from $pV = \frac{1}{3}Nm\overline{c^2}$ and $pV = NkT$.
HSW2

(6) M - Define and calculate the Boltzmann constant
(7) S - Describe the relationship mean KE of particles and absolute temperature
(8) C - Derive and apply the equation for mean kinetic energy

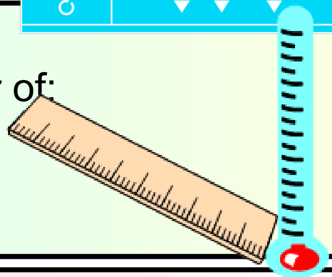
Lesson 7. The Boltzmann constant



STARTER: Estimate by measurement and calculation for this classroom, the number of:

a) moles of gas

b) particles of gas



Kilo 10^3	Remember what atmospheric pressure is in Pa
Mega 10^6	
Giga 10^9	What factors do not affect the number of particles in this room? why?

Key point

(6) M - Define and calculate the Boltzmann constant
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The Boltzmann constant

0:00:00


Key point

The Boltzmann constant is used to relate the mean KE of particles to the gas temperature

R - the molar gas constant is in terms of many particles measured in moles.

K- is a gas constant in terms of a single particle.

$$k = \frac{R}{N_A}$$

Unit
$R = J\ mol^{-1}\ K^{-1}$

$N_A = moles^{-1}$
Unit

What is the value of k? 1.38×10^{-23}

What is the unit? $J\ K^{-1}$

How could the equation of state of an ideal gas be re-written to include k rather that R?

$$pV = nRT$$

$$pV = \frac{N}{N_A} RT$$

$= k$

$$\boxed{pV = NkT}$$

For particles.

(6) M - Define and calculate the Boltzmann constant
(7) S - Describe the relationship mean KE of particles and absolute temperature
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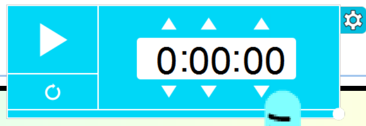
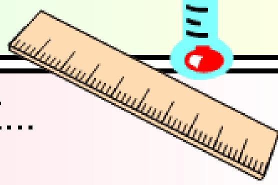
Lesson 7. The Boltzmann constant



$pV = 1/3Nm\overline{c}^2$ $pV = NkT$

ACTIVITY: Compine these 2 equations to find an expression that relates the mean KE of particels of gas, to the absolute temperature of that gas.



Kilo 10^3

Mega 10^6

Giga 10^9

Hint: Look at the general equation for KE...

Ex Activity: Find

a) the mean KE of particles in this room

b) the mean speed of hydrogen in the room

c) the mean speed of oxygen in this room.

Key point

(6) M - Define and calculate the Boltzmann constant
(7) S - Describe the relationship mean KE of particles and absolute temperature
(8) C - Derive and apply the equation for mean kinetic energy

Finding the speed of a particle.

Assume the temperature of this room is 15C. and at this temperature the particles have the SAME mean KE.

Find the r.m.s speed of these particles showing all your steps:

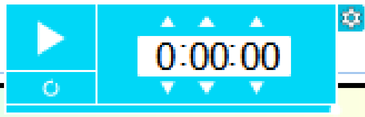
a) Helium atom - Mass- 6.64x 10^{-27} kg

b) Ex: Oxygen molecule Molar Mass - 32gmol^{-1} [redacted]

Extension: Describe and explain how this speed changes if the thermodynamic temperature doubles.

Key point

(6) M - Define and calculate the Boltzmann constant
(7) S - Describe the relationship mean KE of particles and absolute temperature
(8) C - Derive and apply the equation for mean kinetic energy



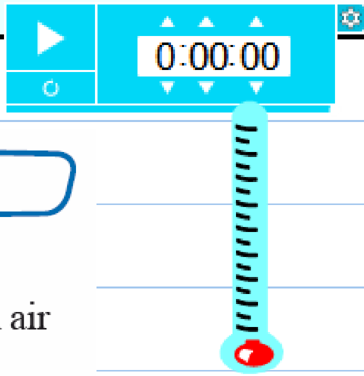
Activity: Complete summary questions p299

Kilo 10^3
Mega 10^6
Giga 10^9

Lowe: p158- 160. Ex18.3 -18.4

Key point

(6) M - Define and calculate the Boltzmann constant
(7) S - Describe the relationship mean KE of particles and absolute temperature
(8) C - Derive and apply the equation for mean kinetic energy



Plenary

19 Air consists of molecules of oxygen (molar mass = $32\,\mathrm{g\,mol^{-1}}$) and nitrogen (molar mass = $28\,\mathrm{g\,mol^{-1}}$). Calculate the mean translational KE of these molecules in air at 20 °C. Use your answer to estimate a typical speed for each type of molecule.

Hint

Hint
The mean kinetic energy of the oxygen or the nitrogen molecules is the same.

20 Show that the change in the internal energy of one mole of an ideal gas per unit change in temperature is always a constant. What is this constant?

Answer

19

Mean KE = 6.1×10^{-21} J;
O_2: $480\,\mathrm{m\,s^{-1}}$; N_2: $510\,\mathrm{m\,s^{-1}}$

20

Internal energy $= E = N_A \times (\frac{3}{2}kT)$;

$$\frac{\Delta E}{\Delta T} = \frac{3}{2}(N_A k) = \frac{3}{2}R$$